DESERT ROSE H20

Proposal Draft

Fredonia Water Use Study

Capstone Prep

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This report highlights important technical aspects to research for a complete water use study for the Town of Fredonia.

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1.0 Project Understanding

1.1 Project Purpose

This project is a complete water use study for the Town of Fredonia, Arizona. The goal is to comprise an analysis of current uses, future predictions, treatment plans and potential alternative sources. Evaluation of water use is important for a municipality to receive water, especially when shared with a neighboring state. Fredonia gets most of its drinking water from Utah rather than Arizona because it is the northernmost town in Arizona, and the closest town is Kanab, Utah. These towns lie alongside tributaries for the Grand Canyon and the Colorado River. Without any significant bodies of surface water nearby, Fredonia's water supply is pumped from surrounding Aquifers.

Although drought conditions for Arizona have improved slightly (Especially Northern Arizona including Fredonia) [1], the threat in the Southwest region is menacing. Lake Mead, which provides a majority of the Southwest with fresh water, is predicted to drop below dead pool in a few decades [2]. As the average surface temperature of the earth increases, so does the rate of evaporation from surface and groundwater. The need for water has also increased alongside the exponentially growing population. Cities across the US are pumping water faster than the reservoirs can replenish, and as a result, severe geotechnical problems have appeared. Water usage is being evaluated in order to ensure that it is being used efficiently. This project is needed to determine the dependency and load Fredonia creates on the local water resources.

1.2 Project Background

Fredonia Arizona is the northernmost city in Arizona, sharing a border with southern Utah. The town occupies approximately 7.5 square miles of land with a population of about 1,300 residents. Figures 1 and 2 of Appendix A show town lines and geographical maps of the site. This small town is about three and a half hours North of Flagstaff and lays on the border to Utah. The soil itself consists of mostly fine sand and clay (Figure 3) which has low hydraulic conductivity, thus, does not absorb as much precipitation [3]. As a result, the town's water supply has to come from a different resource. Currently, the town's water is supplied from nearby rivers such as Kanab Creek, transportation from Kane County Utah and local underground wells. Total water usage averages 498 ac-ft (or 1.623 e+8 gallons) among residential, industrial, commercial and institutional users.

1.3 Technical Considerations

The technical considerations for this project are: potable water sources, wastewater treatment, water quality testing, and software. Water sources include, but are not limited to: Underground water sources from the Redwall-Muav Aquifer on the Colorado Plateau, Transported water from Kane County and precipitation collection. These resources need to be researched using current, credible data. Recycling wastewater as a possible source would require extensive treatment such as analyzing the physical, chemical and microbiological variables, as well as pH, temperature and transparency. In regards to potable water, further testing of physical and chemical properties are required. Such testing would follow EPA requirements set for contamination to ensure the safety of the town's residents. All water testing would help the team separate water demands between residential, industrial, commercial and institutional users to ensure the town's criteria is fulfilled. In addition to physical testing for existing water, future solutions would be modeled using the WaterCAD software. This software will allow the team to manage existing infrastructure as well as design and test new solutions. The following sections explain in detail the technical considerations for the project.

1.3.1 Drinking Water Sources

Water resources of Coconino County include groundwater reservoirs, transportation from Kane County in southern Utah, and precipitation [4]. From Kane County, Utah, approximately 498.7-acre feet (ac-ft) of water are transported per year into Fredonia. This accounts for approximately 62% of the total available water supply [4]. A secondary water source includes groundwater wells within the Redwall-Muav Aquifer located on the Colorado Plateau in Northern Arizona. The water levels below the ground surface range from 320 ft to 2980 ft with an average saturation thickness of 1,360 ft [5]. Due to the geologic structure, channel features and recharge distributions the hydraulic gradient ranges from 4.4 to 88 ft/mi. The available underground water resource leads to the possibility of the installation of groundwater wells. Three wells, located about 12 miles from the town, are shown in Figure 2 of Appendix A, could be used as potential water sources. However, the cost and feasibility would need further research. A third possible source of water comes from precipitation. The annual precipitation rate from 2016 ranged between 10 and 15 inches. If collected using proper rainwater catch systems, this could yield up to .5 Ac-ft (roughly 140,000 gallons) of water per year, given the minimum annual precipitation rate of 10 inches [6]. Although the system is possible, it has a significantly lower collection rate than what is brought in from Kane County.

Regardless of what resource is used to supply water, quality testing is needed to ensure the safety of the residents. Further research into quality testing will be performed once the team has water data provided by the town of Fredonia.

1.3.2 Wastewater

Wastewater is non-potable water drained out of residential and/or industrial sites through sinks, toilets, washing machines, etc. It also includes storm runoff and other sources of water that flow into the sewage system [7]. Wastewater also requires water quality testing before leaving the respective facility. These tests analyze the physical, chemical and microbiological variables and can be carried out in the field. Some variables must be measured in the field, either in situ or very soon after the sample has been collected [8]. Field analysis is needed for temperature, transparency and pH [8].

Each building in Fredonia has its own septic tank, which collects wastewater to transfer it to a wastewater treatment plant. Fredonia's wastewater treatment facility generate 157 ac-ft of effluent per year. The treated effluent is disposed into and evaporated in evaporation ponds [9].One of the most pertinent issues with septic tanks is the possibility of overflow--either from overuse or surface water seeping in. In the event of overflow, harmful bacteria can be introduced to the local water systems. This is why an integrated sewer system or effective septic waste disposal will be a focus for this project.

1.3.3 Water Users

The population of the town was 1,317 residents according to the 2014 census [10]. Since it is a small, rural town, there are very few large commercial or industrial water users. The main users are: residents, institutions, commercial businesses, and farms. These numbers were deduced from Kane County's Municipal and Industrial Water Supply and Use report with information collected in 2005 [4].

Residential

The largest consumer of water in Fredonia are the residents. There are 1,002 households in town that contribute to the consumption and waste of utilities [10]. Out of the 498.7 ac-ft of water provided from Kane County, 431.8 ac-ft goes towards indoor and outdoor residential use [4]. This makes up 86.6% of Fredonia's water. This water is used primarily for household purposes like watering the lawn to bathing.

Institutional

The second largest users of water in Fredonia are institutions like schools and government offices. There are two schools nearby - Fredonia Elementary/Middle School and Fredonia High School. These institutions use about 9.2% of the town's water.

Commercial

There are a few restaurants, inns, businesses and manufacturing companies in Fredonia, but still collectively use less water than residents or schools. Commercial businesses use less than 3% of the community's water. This is probably because fewer people occupy these buildings for a shorter duration.

Industrial/Stockwater

Kane County provides water for Fredonian farms and or industrial complexes with about 7.9 Ac-ft, or 1.6% of their total water use [4]. It is unclear so far whether the users are agricultural or industrial, but considering the population of the town, a large industrial complex is unlikely. More research is needed to find the exact use and distribution of water and the information will be updated accordingly.

1.3.4 Software

There are different types of software that can be used to analyze water supply and use, but the best will be WaterCAD. Engineers trust WaterCAD, because it is a reliable, supportive tool for infrastructure decisions. It can design new water systems and manage existing water networks effectively to reduce disruption risks and energy use [11]. It can mainly increase capacity to adequate service levels, supply clean potable water without interruption, and deliver high quality designs cost effectively [11]. A second software that can be used during the study is the Geographic Information System (GIS). GIS is an effective tool for storing, managing, and displaying spatial data often encountered in water resources [12]. To use GIS software, applications related to this area are addressed and evaluated for efficient future research and development [12]. Microsoft Office will be used during this project to draft all documents and computations. Every team member will contribute researched data, as it might help with creating graphs and spreadsheets.

1.3.5 Water Testing

The team will conduct different tests on water samples collected from the city of Fredonia to analyze the water quality. Since Fredonia is located 194 miles from the team's headquarters in Flagstaff, AZ (as shown in Figure 2), the team will need to make proper arrangements with the town officials to plan a site visit and test date. Physical, chemical, and bacterial tests will be conducted according to the need. The tests include (but are not limited to) Odor, taste, pH level, bacteria, and lead. Samples will be collected from potable water, wastewater, and reclaimed water sources. These tests will follow the approved EPA standard methods for testing for contaminants found under Title 40 in Code of Federal Regulations (40 CFR).

Testing the water quality will help the team separate the water sampled into different categories. Also, it will help determine if water can be utilized in residential, industrial or other usages.

1.4 Potential Constraints

There are several potential challenges that could constrain the project like misinformation, water quality and finance. The town of Fredonia will provide data for water use, but until we make contact, information will be taken from ambiguous public and government records. This miscommunication may result in an error in the results. This will be overcome once we have the chance to visit Fredonia in person.

Arizona's Department of Environmental Quality sets strict standards on the quality of drinking and non potable water so no contaminants enter the network. As it is described in the section above, water quality tests constrain the city's water supply and our testing methods

Finance is also a concern because government work is funded by tax dollars - a sensitive topic. We must guarantee these tax dollars are being used efficiently and effectively by focusing on the objective.

1.5 Stakeholders

The stakeholders for this project are: the Town of Fredonia, its residents, Coconino County, Kane County, Northern Arizona University, and the Desert Rose H2O team.
The Town of Fredonia is the main client who requested this analysis. This study affects this small town because it has a complicated water deal with multiple jurisdictions. The residents of Fredonia, although oblivious to the project, are the users of the water study being conducted. The distribution, businesses and demographic directly affect the amount of water consumed per capita. Fredonia is located in Coconino County, Arizona, and gets a portion of its water supply from aquifers underneath it. Since Fredonia is too small of a city, the county office in Flagstaff manages much of the bureaucratic agenda. On the other hand, Kane County, Utah, is where the most exchange of goods and services occurs. Kane County provides Fredonia with drinking water as well as access to the hospital and airport. Northern Arizona University is involved because this study was requested as a senior capstone project. The public image of the university is on the line with team Desert Rose H2O because we represent the student population, and it is our responsibility to uphold the reputation of producing excellent graduates. The team is also physically, financially and emotionally invested in the project because we have spent the last few years preparing for a capstone proposal, and we will have to travel hundreds of miles to make site visits.

2.0 Project Scope

The following is a list of tasks needed to be completed next semester in order to finalize the Fredonia Water Use Study. The team has conducted research on technical aspects and have touched bases with clients and advisors. This scope and schedule will be subjected to change once new information is obtained. Tasks remaining for this project include but are not limited to: cite visits, sample testing, public outreach and computer modeling. Each task is defined and expanded into subtasks in order to clearly explain every step. Additionally, this document clarifies any exclusions from the project.

2.1 Task 1: Data Collection

Gather previously recorded data regarding the water usage information. Sources include actual water usage data from the town, previous projects, and county records.

2.1.1 Review Data

The team will review the current existing data about Fredonia's water supply and usage in hopes of gaining understanding about the current situation. This includes location of wells, water volumes collected from wells, and two-year water usage.

2.2 Task 2: Pre Site Visit: Teleconference

Before the team makes its first site visit, information needs to be acquired. Discussing the project with the town manager and clerk will add more items to this scope. This will help the team clarify a list of questions about current water usage and develop the survey intended to distribute to town residents.

2.2.1 Inform Residents: Pre Visit Resident Outreach

Town residents will be informed about the team's involvement with the project and the dates that the team will be conducting research. Since the team plans to conduct a public survey, the residents need to be alerted as to the intentions of the survey questionnaire.

2.3 Task 3: First Site Visit

The team will visit the town in person to gain a better understanding of the project and environment. During the first visit, the team will complete the following activities: Meet with the client to discuss progress on the project, evaluate current water sources, and photograph existing water sources. The team will also make a schedule to return for a second client meeting.

2.3.1 Resident Survey

The team will create a simple survey to gather personal opinions of the water supply from citizens of Fredonia. This survey will contain a few short questions about the quality, need, supply, and usage. The team plans to ask residents to fill out a survey at the local supermarket. Hopefully the participation will be high due to the pre visit outreach.

2.3.2 Photograph Sites

To ensure proper data collection for the next visit, the team will visit sites within Fredonia to become familiar with the location. This includes photographing current water sources, the town and any other items the team decides are necessary. These photos will be used in the project website.

2.4 Task 4: Identification of Alternative Sources

Part of the study is to identify possible new sources of drinking water for Fredonia. If a new water supply is discovered, it must be tested for quality to ensure safety to health.

2.4.1 Possible Testing

If a new source of water is identified, testing will be conducted to characterize the water.

2.4.1.1 On-Site Testing

Temperature and pH will be tested on site. The testing will be conducted according to Title 40 CFR chapter 141.

2.4.1.2 Post-Visit Testing

The samples will be gathered then tested at Northern Arizona University. The testing will be conducted according to Title 40 CFR chapter 141. The Team will conduct a method detection limit test, which measures the minimum concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results [13]. This test will analyze the chemical, physical, and biological components of wastewater. Equipment necessary to complete sampling is provided in the waters lab at NAU.

2.5 Task 5: Report

A final report and presentation will be given at the end of the Fall 2017 semester which will include the tasks mentioned above. This presentation will summarize and conclude the project.

2.6 Task 6: Project Management

This section outlines the administrative aspect of the project including meetings and the project website. It is important to maintain good communication and relations with the town and its residents through updates and respectful visits.

2.6.1 Meetings

There are several types of meetings conducted throughout the project: client, technical advisor, phone, and group. The first meeting with the client, William Way, was a phone interview on Wednesday, February 22, 2017. This time was used to clarify questions about the project overall. The team also met face to face with the technical advisor, Dave Monihan, later the same afternoon. These meetings required an agenda be created at least two days prior to the event. Meeting minutes were kept by a different team member each time as well.

2.6.2 Website

Each capstone project requires a website that will introduce and summarize the project. This website archives the work students have done and acts as a portfolio for future employment opportunities. This will also be used to communicate with the community and a way for residents to reach out to the members.

2.7 Exclusions

As specified by the client, a water study will be conducted. This study includes research of existing sources, potential future sources and water conservation efforts. This project does not include any floodplain, municipal network, or water collection system design. Existing designs may be analyzed but no new designs will be proposed. There will be no physical end product or prototype.

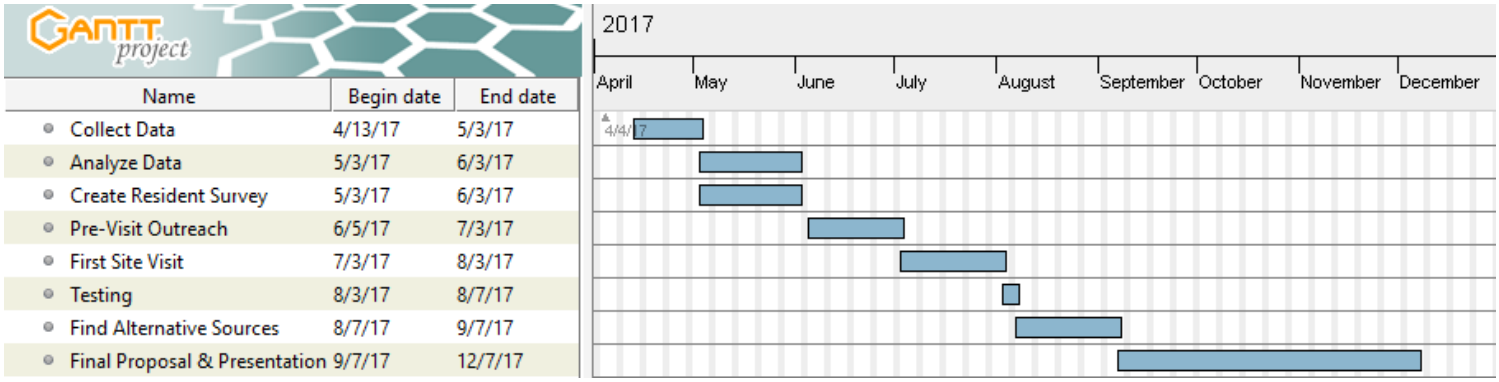
3.0 Schedule

The following compiles each task with its deadline. As the team continues meeting with the client and technical advisor, more tasks will be added to the list. These will include definitive dates once the client interview is conducted and the schedule for next semester is confirmed.

3.1 Project Tasks

Name	Begin Date	End Date
Collect Data	4/12/17	5/3/17
Analyze Data	5/3/17	6/3/17
Create Resident Survey	5/3/17	6/3/17
Pre-Visit Outreach	6/3/17	7/3/17
First Site Visit	TBA	8/3/17
Testing	8/3/17	8/7/17
Find Alternative Sources	8/7/17	9/7/17
Final Proposal & Presentation	9/7/17	December 2017

3.2 Gantt Chart



Name	Begin date	End date
Collect Data	4/13/17	5/3/17
Analyze Data	5/3/17	6/3/17
Create Resident Survey	5/3/17	6/3/17
Pre-Visit Outreach	6/5/17	7/3/17
First Site Visit	7/3/17	8/3/17
Testing	8/3/17	8/7/17
Find Alternative Sources	8/7/17	9/7/17
Final Proposal & Presentation	9/7/17	12/7/17

Figure 1: Gantt Chart

4.0 Staffing and Cost of Engineering Services

4.1 Team Member Roles

The roles of each team member are as follows.

Abdulrahman Alkandari - Water Quality Test Manager, Surveyor, EIT
Abdulaziz Malek - Surveyor, Water Quality Tester, EIT
Stephen Taylor - CAD Drafter, Editor, EIT
Hanako Ueda - Team Manager, CAD Drafter, EIT

The water quality test manager is responsible for collecting, transporting and testing water. If the team discovers a new water source, a New Source Monitoring test will be conducted by the water quality test manager.
The surveyor will collect topographic data points of the new water source location, if one is discovered.
The CAD drafter will convey the surveyed points to a computer generated topographic map, as well as any blueprints or plans sets.
The editor proofreads final documents and approves them for submittal.
The team manager is responsible for assigning tasks and ensuring work is completed before deadlines. It is the manager's job to schedule meetings and accommodating team needs.
An engineering in training is the status of the individual in the professional engineering world. It is an assumption that Desert Rose H2O company members are recent college graduates who do not possess a P.E. license.

4.2 Hired Staff

All staff completing the project are assumed to be working for the Desert Rose H2O company. This eliminates any additional fees associated with subcontracting outside companies to complete tasks. As the project nears completion, total man hours used will be totaled and factored into the cost analysis.

Table [1]: Hired Staff

Staff Title	**Number of Individuals**	**Estimated Hours**
Engineer in Training	4	97
CAD Drafter	2	10
Non-Registered Land Surveyor,	2	32
Water Quality Tester	2	18

4.3 Project Costs

The project costs include any items necessary to complete the project. The costs below are broken down into the amount of each item needed, cost per item and total cost.

Table [2]: Fixed Project Costs

Item	**Amount**	**Cost (Per Amount)**	**Total Cost**
Travel	400 miles	$0.23	$93.99
Printing	548 Flyers	$0.20	60.28
Lodging	2 Rooms, 1 Night	$77.00	$154.00
Newspaper Ad	2” x 3” Ad	$7.25 per inch	$43.50
Testing	1	$220.00	$220.00
			∑ = $571.00

*All costs are subject to change and new services and fees may be added or subtracted to the final cost proposal

4.4 Staff Hourly Costs

Staff hourly costs are based on the 2017 Standard Rate Schedule. All hourly costs include all overhead fees, billing, worker wages. To reduce additional fees, all services are completed within the Desert Rose H2O company; negating the need to subcontract third parties to complete additional services. The staff hourly wages are broken down and shown in Table [3] below.

Table [3]: Staff Hourly Costs

Staff Title	**Hourly Wage**	**Total Hours**	**Total Cost**
Engineer in Training	$90.00	97	$8,730
CAD Drafter	$80.00	10	$800.00
Non-Registered Land Surveyor, Party Chief	$95.00	32	$3,040.00
Water Quality Test Manager	Fixed, see Table 2	18	$220.00 (excluded)
			∑ = $12,570

5.0 References

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